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ΘΕΜΑ: DRY DOCK A VESSEL (WHY, WHEN, HOW, WHERE)

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CONTENTS

Affirmation

I certify that I am the author of this diploma thesis and that any help I will get during the preparing of her will be mentioned in the thesis. Moreover I declare that this thesis is prepared personally by me especially for the program requirements of the Merchant Marine Academy with the help and guidance of my supervising professor.

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Abstract

The purpose of this diploma thesis is to describe the procedure of dry docking a vessel and analyze main parts of shipbuilding. Moreover reference is being made to all stages of vessel construction on a shipyard. The thesis is organized into three chapters. In the first chapter the process of building a vessel is being analyzed and general information about the shipyards is given. Also the procedure of how they operate and the technology they use is being described. Finally a survey is cited on the upcoming dry docks in order to see which shipyards are going to have an impact in the future of shipbuilding.

In the second chapter information is given about repairing a vessel and the types of dry docking. Also reference is made to the accidents that have led to the adoption of the existing regulations. Furthermore evaluation of the costs has been made according to each type of vessel and the types of dry docking.

On the last chapter the final part of the vessels life is being described, where the owners want to have as much profit as they can and this may end up in serious problems like accidents and pollution. Moreover the procedure of the dissolution is being analyzed and the new regulations adoption is being presented.

Chapter 1: Building a vessel

1.1: Ship construction and the Maritime industry

The 95% of the world's merchandise is being transferred by commercial vessels. Below I will present the history and the evolvement of vessels, as well as the process of construction. The first known vessels date back about 10,000 years ago, but could not be described as ships. The first navigators began to use animal skins or woven fabrics as sail. Affixed to the top of a pole set upright in a boat, these sails gave early ships range. The first sea-going sailing ships were developed by the Austronesian peoples from what is now south china and Taiwan. Their invention of catamarans, outriggers, and crab claw sails enabled their ships to sail for vast distances in Open Ocean. Also in 3000 BC, Ancient Egyptians learned how to assemble wooden planks into a hull. They used woven straps to lash the planks together, and reeds or grass stuffed between the planks helped to seal the seams. However we cannot talk for dry docks until 2600 B.C in Harappa port city of Lothal circa in Gujarat, India where the world's earliest known dockyards were built. Despite the fact that the technology of the vessels was improving no one had thought about building a place not only for producing ships but for repairing them as well. It was until 1088 in china when they first thought the need to have a place for maintenance. However it took 4 centuries to transfer this knowledge from Asia to Europe, so we reached 1495 in order to build the first dry dock, which was built in England at Portsmouth. Possibly the earliest description of a floating dock comes from a small Italian book printed in Venice in 1560, which is shown below.
Construction features of those European establishments were embodied in the first federal dry dock erected in the United States, a 253-foot graving dock completed in Boston in 1833 Ship designs stayed fairly unchanged until the late 19th century. The industrial revolution, new mechanical methods of propulsion, and the ability to construct ships from metal triggered an explosion in ship design. Factors including the quest for more efficient ships, the end of long running and wasteful maritime conflicts, and the increased financial capacity of industrial powers created an avalanche of more specialized boats and ships. Ships built for entirely new functions, such as firefighting, rescue, and research, also began to appear. Nowadays there exist hundreds of shipyards, some for building and repairing vessels and some just for dismantling them.

1.1.1: Types of building a vessel and the technology they use

There are different types of dry docks that are used for repairing and cleaning the ship's bottom part. These are listed below:

1.Graving dock
2.Floating dock
3.Marine Rail Dock
4.Ship lifts
5.Marine mobile lifts

Among these, the marine mobile lifts and ship lifts are mainly used for small vessels such as recreational yachts, tugs pilot boats etc. Nowadays, there are mainly two types of dry dock procedures from the above lists which are used for seagoing vessels: graving dock and floating dock. These will be presented next.

1) Graving dock:

This type of dry dock is normally constructed on land near the coastal water with a rectangular solid concrete construction with blocks, walls, and gates. The vessel is shifted inside the dock and rested in the blocks. After the ship is in the required position, the gate is closed and water is removed.

2) Floating dock:

A floating dock is in the form of "U" structure which is mainly used in salvage, to carry ships that have encountered an accident and are damaged to an extent that has made them unable to sail further to a coastal dock. However, now many regular sea-going, small and mid-size vessels are also dry docking in a floating dock. Several "U" type floating docks can be joined to carry a large vessel.

The ship is brought near the channel where the floating dock will partly submerge itself and the ship slides inside the dock. Once the ship is in the position, the floating dock is then de-ballasted to drain the water from its hollow floors and walls to support the vessel on the blocks arranged on the floor of the floating dock.

The criteria to select a type of dry dock are based on the following factors:

- **The size of the vessel:** The graving dock is used to accommodate larger size as compared to any other type. If the ship owner/ manager has to dry dock a large oil tanker, they will go for graving dock. If the vessel is about 10000 tons, Marine railway type can be used. If a boat or small yacht of up to 250 tons needs a repair in the dock, a mobile marine lift can be used
- **The condition of the vessel:** If the vessel propulsion plant is not working or there are damages which can make a vessel immobilized, floating docks are commonly used in such

condition

- **Types of repair:** The choice of the type of dry dock also depends on the types of repair the ship wants to undergo. For the normal scheduled dry dock, a floating dock can be selected, however, if major retrofitting needed or massive parts/ machine fitting is required, the graving dock is selected as they are usually located near to the shipyard and it is easy to move the material from land to dock in comparison with floating dock.

- **Schedule of the vessel:** The location and the type of the dry dock will be decided as per the current schedule of the vessel and how easy it is for the ship to reach the dock after unloading all the cargo to the last port of call

Budget: The most important factor to select the type of dry dock is the budget allotted to the ship

1.1.2: Time needed to build a vessel according to each type and the costs of it

The time and the cost of building a vessel depends on a variety of factors such as the type of the vessel, the shipyard that has taken over the project and the time that the ship owners want it to be delivered. Below, some examples will be given for some main categories of vessels because all the types of all sizes cannot be described in a thesis.

Beginning with the cruise ships, the cost of building a cruise ship generally depends on the vessel's size, the building shipyard (labor prices, taxes, quality of service), the onboard features (facilities and amenities) and finally - on the economy itself. So generally the cost for big cruise ships is between 150 million us dollars to 1.4 billion us dollars, a price which belongs to the biggest cruise that exists. Of course the time needed to be built is not standard but on cruise ships, it is between 1.5-3 years, but this only includes the building and not the planning, drawing and more.

Moving on to container vessels in 2015 the average construction cost of a container ship was USD 64 million. It is clear that due to the increase on demand in all size categories, there has been a decrease in the nominal construction costs. In the case of ultra large ships, decreasing costs have likely resulted from improved construction techniques. The first 15000 TEU ships were built by Maersk in 2006: prior to this, no shipyard had any experience in building such a large container vessel. Over the course of the next few years, however, several competing companies have placed orders with a variety of builders, driving down costs. In addition to the general trend of decreasing costs, it is clear that larger vessels generally carry larger price tags. This change in nominal cost over time is interesting, but it is not the focus of this analysis. As can be seen below, there are huge

changes in prices from time to time. As to the time required, it takes about 10 months to 18 months just for the building.

Moving on to tanker vessels. The price for shipping oil using tankers varies. The cost for oil tankers in 32,000-45,000 DWT is US$43 million, while the 80,000–105,000 DWT costs $58 million. The 250,000–280,000 DWT oil tankers cost $120 million. Construction of crude oil tankers takes 9 to 15 months from the time the keel is first laid. This means that it will take at least two years from the time of new building contract signature (ordering) until the vessel is delivered because many critical parts are long-lead items that needs to be ordered and produced before the construction of the ship can commence.

The next type of vessel is bulk carriers. The time to build them is little less than the aforementioned types because it is little simpler vessels, so the time is between 7 to 13 months. The cost of course depends on the size, as presented in the table of approximately costs in 2009 survey.

	Type of Ship	DW [t]	Price [US Mill]
Bulkcarriers	Handymax	56,000	30,5
	Panamax	76,000	35,5
	Capesize	180,000	56

http://www.mar.ist.utl.pt/mventura/projecto-navios-i/en/sd-1.3.2-cost%20estimate.pdf

The next category is Lng vessels. In most cases, it takes 30–50 months to complete the construction of such a vessel after the order is confirmed. However, the different type of propulsion system also affects the delivery schedule of the vessels. For example, when DFDE vessels were first ordered in the early 2000s, it took longer time to be delivered as shipyards need longer time to apply the new propulsion technology. The delivery time of DFDE carriers between 2006 and 2010 reached an average length of 50 months, but cut down to 37 months after 2010. If a sister ship is ordered, the delivery time can be reduced to within 24 months, because few modifications are required in design. As you can see below, the cost depends on how the market evolves on the specific year and something that cannot be shown on this picture is that in 2019 the cost has dropped to 190 million dollars unlike 2018 that was 10 million up.

The next category is Ro-Ro vessels. This is a type which is partly new to the maritime industry. The biggest vessels from this type cost approximately 50 million us dollars and take 5 months only to 9

to be built. Below the prices for some other categories are presented together, which will not be described herein.

Vessel type	Average vessel size 2007 fleet (ton (dwt))	Engine size 2007 fleet (kWh)	Average new building price 2007 fleet (Million USD)	Average vessel size EOS fleet (ton (dwt))	Engine size EOS fleet (kWh)	Average new building price EOS fleet (Million USD)
Dry bulk	52,500	8000	32	172,000	15,000	59
General cargo	4600	2100	11	25,300	8000	27
Reefer	5400	5000	15	16,100	15,000	29
Container	34,200	22,000	44	106,000	67,000	98
RoRo	7200	7500	32	44,600	20,000	93
Crude oil	142,900	15,000	65	295,200	25,000	98
Oil products	10,200	2700	15	112,100	15,000	57
Chemicals	15,800	4500	28	47,600	9000	54
LNG	70,100	25,000	162	76,300	27,000	170
LPG	11,600	4500	28	53,300	13,000	64

http://www.mar.ist.utl.pt/mventura/projecto-navios-i/en/sd-1.3.2-cost%20estimate.pdf

1.1.3: Numbers of new building vessels and the predictions of the future

The total number of vessels according to Equasis statistic that was published for 2018 is 116.857, but from this we will talk only for the almost 53.000 vessels, because we will mention the fishing vessels, tugs and similar vessels. Of the around 53,000 merchant ships trading internationally, some 11,000 ships were bulk carriers. General cargo ships accounted for the majority of ships in the world merchant fleet as of January 1, 2019.

	Number of ships
General cargo ships	16,945
Bulk cargo carriers	11,562
Crude oil tankers	7,444
Chemical tankers	5,734
Container ships	5,152
Ro-Ro/ Passenger ships	4,812
Liquefied natural gas tankers	1,98

file:///C:/Users/%CE%B8%CF%83%CE%B5%CF%81/Downloads/Equasis%20Statistics%20-The%20World%20Fleet%202018.pdf

1.2: Location and general information of the biggest shipyards in the world

There exist hundreds of shipyards in the world but some of them have a contributory factor in merchant shipping. According to the latest surveys these are the 10 biggest Shipbuilders in the

world in terms of Gross Tonnage (GT):

10. Shanghai Waigaoqiao – Shanghai, China

Shanghai Waigaoqiao shipyard is the number one shipbuilding company in China with the total gross tonnage production until date of 15, 096,900 GT, which includes164 ships of various types and sizes.

9. Imabari Shipbuilding – Marugame, Japan

Imabari Shipyard built the world first vehicle Carrier –"American Highway" and has delivered VLCC of 300,000 DW. The Gross tonnage production till date is 15,692,687 GT which includes 393 ships.

8. Hyundai Mipo – Ulsan, South Korea

One of the most versatile production houses in terms of conventional and specialised vessels, Hyundai Mipo is famous for delivering mid-size chemical tanker and Panamax container ships. The Gross tonnage production till date is 16,715,650 GT which includes 618 ships

7. Oshima Shipbuilding – Oshima, Japan

Oshima Shipbuilding has a specialization in building bulk carrier ships with gross tonnage production till date of 16,983,004 GT which includes 539 ships.

6. Tsuneishi shipbuilding – Numakuma, Japan

Tsuneishi is the leading shipbuilding company in Japan with specialization in building medium sized Bulk carrier ships. The Gross tonnage production till date is 17,824,038 GT which includes 492 ships.

5. Mitsubishi Heavy Industry – Nagasaki, Japan

Second in rank within Japan and 5th in the world, Mitsubishi H I has its specialization in commercial vessels such as oil tanker and cruise ships. The total gross tonnage production till date is 19,506,548 GT which includes 315 ships.

4. Hyundai Samho – Samho, South Korea

Another Key player from Korea, Hyundai Samho is located in Yeongam with production capacity of approximately 40 vessels per year. The Gross tonnage production till date is 28,414,515 GT which includes 372 ships.

3. Samsung Heavy Industry – Geoje, South Korea

Samsung H I shipbuilding company is one of the top three shipbuilders in the world with specialization on special purpose vessels like FPSO, LNG etc. The total Gross tonnage production till date is 58,082,349 GT which includes 785 ships.

2. Daewoo Shipbuilding – Okpo, South Korea

Another giant in this sector and second in the world is Daewoo Shipbuilding, located in Okpo and known for its sustainable and giant ships. The future delivery includes much talked about Maersk EEE class vessels. The total production of Daewoo shipyard is 68,284,087 GT which includes 834 ships.

1. Hyundai Heavy Industry – Ulsan, South Korea

The Leader in the Shipbuilding sector, Hyundai Heavy Industry is based on Ulsan with a record of 93,893,700 GT which includes 1428 ships of various types and sizes.

As you can see a major part of shipbuilding takes place in just three countries, which also belong to Asia. This happens for three reasons, first because they have a huge advantage in technologies compare to other countries, secondly due to theirs country population they manage to have all this workers and third they have financial support from the government.

1.2.1: Differences between dry docks for all the phases of the life of a vessel (Building, Repairing, Dissolution)

Word shipyard is a simplex one because there are three types following the same word. Despite the fact that all dry docks follow a totally different procedure, they can be separated into three kinds of shipyards.

First there is the dry dock for building vessels, which has specific equipment such as floating cranes for the transfer of the separate parts of the vessel on the beginning of its construction and of course specialized staff such as designers and departments of researchers.
Second there is the dry dock for repairing vessels which of course does not have all the above and has all the necessary departments only for repairing such as painters and fitters. It is common for a shipyard to have the facilities for only one of them but in some occasions in big shipyards they have both facilities for building and repairing as in Samsung shipyard industries.
Last there is the dry dock for the final part of a vessels life which is the dissolution. This is also called shipyard despite the fact that nothing is built there but only destroyed. This happens in order to remove all the metals and the equipment from the vessels, but because it is a total different procedure from the above mentioned you cannot find a dry dock that combines both. Moreover, not a lot of countries, especially over the last years, wanted to have a dry dock for dissolution because with the measures implemented over the previous decades it resulted in serious pollution of the areas and the seas.

1.2.2: Upcoming shipyards

In order to save their economy, some of the biggest shipyards in the world like the ones in China and South Korea have decided to make a corporation with other shipyards. Some others developing countries have decided to build huge dry docks that will enable them to counter with the needs of the modern shipping industry. I will present herein the cases of South Korea and China, in combination with the cases of India, Saudi Arabia and Greece.
First starting with South Korea Shipyards, in South Korea they are trying to forge a new shape for the industrial sector that underpins global shipping. The merger of Hyundai Heavy Industries Co. and Daewoo Shipbuilding & Marine Engineering Co. being engineered in Seoul promises to create a behemoth controlling 20% of the global market for new ships, and an even bigger share of the market for the liquefied natural gas carriers that are reconfiguring global market energy. The combination also would leave rival yards in China and Japan struggling to compete, raising questions about those countries' commitment to supporting their own ship builders. Shipbuilding is a vital part of the economies of Asian countries such as South Korea and China, employing hundreds of thousands of people. Seoul and Beijing repeatedly bailed out or subsidized money-losing shipyards during a long slump in maritime trade as vessel operators trimmed their fleets and new orders plummeted. The merged Korean superyard may benefit the most. Between them, HHI and DSME have 52% of existing orders for LNG carriers, and they control a fifth of the broader ship building market, according to marine data provider Vessels Value. The total combined Korean order-book now is worth $31.4 billion, compared with $15.2 billion for China's top two

shipyards—China State Shipbuilding Corp. and China Shipbuilding Industry Corp.—which also plan to merge. “Our effort over the past five years was to keep HHI and DSME from sinking,” has stated a senior Korean official involved in the merger. “The target now is to create a yard facility that will dominate ship orders, especially high-margin vessels like LNG carriers, for years to come. LNG ships cost on average $175 million apiece and the profit margin for the companies that build them is almost double that of other vessels, according to shipbuilding executives. Bulk carriers typically cost around $25 million each.

China is the biggest shipbuilding country of the last years as to the numbers of vessels they produce and not to the gross tonnage. China has announced the merger of the country’s two largest state-owned shipbuilding giants, a step Beijing has been preparing for nearly a decade to strengthen the competitiveness of its shipbuilding industry. The intention to merge the Shanghai-based China State Shipbuilding Corp (CSSC) and the China Shipbuilding Industry Co (CSIC), based in Dalian, Northern Liaoning province, was announced in a statement on the website of the state-owned Assets Supervision and Administration Commission of the State Council, China’s cabinet. According to a source familiar with the merger plan, the merger would enable China to establish a shipbuilding giant with combined revenue up to 1 trillion Yuan (US$141.5 billion), capable of building vessels ranging from warships, like aircraft carriers, to civilian ships such as container ships and oil tankers, said a source familiar with the merger plan. This merger has been in the making since Hu Wenming, a former party leader of the state-owned aviation industry, was assigned to CSSC as party secretary in 2010,” the source added, requesting anonymity because of the sensitivity of the issue. The merger plan was put on the drawing board at a time when the world shipping industry had entered a golden period in 2009, and the business of CSSC and CSIC was at its peak, but China’s analysis indicated a decline was on the horizon, as has actually happened in recent years.

Apart from the biggest dry docks in the world there are some others upcoming shipyards that stand out. First, in India, Cochin Shipyard Limited (CSL), the largest Public Sector shipyard in the country in terms of dock capacity, has set the course to construct a larger and more dynamic drydock. The Chief Minister of Kerala & Honble Minister of shipping conducted the ground breaking for the third drydock of the company to be located in the northern end of the shipyard. The new dock will have a length of 310 m. It is a stepped dock with a width of 75 M at the wider part and 60 M at the narrower part. It will have a depth of 13 M and a drought of 9.5M. This will be the largest and more dynamic dock in terms of vessels that can be docked. The stepped dock concept enables longer vessels to fill the length of dock; and wider, shorter vessels and maritime equipments such as jack up rigs to be repaired /constructed at the wider part of the dock. Again, in terms of the size of the dock and strength of the dock floor, this will be one of the largest dry docks in India. The new dry dock will be equipped with one gantry crane of capacity 600 T, two LLTT cranes of

capacity 75 T each and other allied facilities, with an option to add another 600T gantry crane at a later stage. The new drydock, when commissioned, will help the company to have a more diversified product profile.

This dual purpose dry dock is planned essentially to tap the market potential of repairs/construction of specialized and technologically advanced large vessels such as LNG vessels, Jack up Rigs, Drill ships, large Dredgers, Second Indigenous Aircraft Carrier and repair of offshore platforms and larger vessels. The new dry dock can comfortably handle Aircraft carriers of 70,000T docking displacement and Tankers and merchant vessels of 55,000T docking displacement. The Dock floor is designed to take a loading of 600T/m. The design caters for sufficient safety margins as per international codes.

In Saudi Arabia, King Salman International Complex for Maritime Industries and Services in Ras Al Khair will cover 4.3mn sqm. Sepco Electric Power Construction Corporation has awarded his engineer a contract to deliver engineering services for Packages 4, 5 and 6 on the King Salman International Complex for Maritime Industries and Services project at Ras Al Khair, Saudi Arabia.

In Greece, the country that has the biggest fleet in the world, there is not even one big shipyard in operation. Three months ago, a decisive contract for Greece shipyard skaramagas was signed by Chatsworth Securities Llc and Onex Elefsis Shipyards, Llc. This contract includes the financing of 400 million us dollars on the next 15 years to the dry dock in order to make it full operational and save it from closing. After that the dry dock will be able to build or repair vessels with deadweight 200.000 tons.

1.2.3: Biggest vessels that have ever been built

One cannot argue which is the biggest vessel of all times is because of the differences in each category, so I will describe the biggest commercial vessels of each category to date.

1) The largest containership – the megamax and the OOCL Hong Kong

OOCL at 21,413 teu was the first vessel to break the 20,000 teu mark. The vessel is 399.8m long, by 58.8m across, with a depth of 32.5m and 191,317 dwt.

2) The world’s largest bulkers – the Valemax and the Vale Brasil

The very large ore carriers (VLOCs) built for Brazilian miner Vale are the world’s largest bulkers

topping out at 400,000 dwt. These giants of the seas were ordered when the dry bulk freight market had hit its peak of $300,000 per day in 2008 for a capesize and were designed to keep Vale's iron ore exports competitive given the high cost of freight and the longer distances from Brazil to China versus competing exporters based in countries such as Australia.

The first of the 400,000 dwt Valemaxes was the Vale Brasil, now the Ore Brasil, which came into service in 2011. The vessel was 362 m long, by 65 m breadth and 30.4 m in hull depth with deadweight of 402,000 dwt.

3) The largest tanker – ULCC Jahre Viking

The 564,763 dwt ultra large crude carrier Jahre Viking, as it was known for the majority of its life, was delivered in 1979 as the Seawise Giant from Sumitomo Industries in Japan. The largest tanker ever built it is the only vessel on this list that is no longer in service and was scrapped in 2010. Some 458.45 m in length the Jahre Viking was to prove to be something of a white elephant reportedly never carrying a full cargo in its 20 years in service. Following its construction the very large crude carrier (VLCC) in the 300,000 dwt range was to become the standard size for the largest tankers dovetailing with the largest crude oil cargo sizes of 2m barrels or 300,000 tonnes.

4) The world's LNG carriers – the Q-Max

The 266,000 cu m sized Q-Max vessels owned by Qatargas are the world's largest LNG carriers. A total of 13 Q-Max vessels were built at Hyundai Heavy Industries, Samsung Heavy Industries and Daewoo Shipbuilding and Marine Engineering and have membrane type cargo containment systems. The vessels have twin slow-speed diesel engines and are 345 m in length, 53.8 m in breadth, and 34.7 m in height. The Q-Maxes were delivered between 2008 and 2010. According to Qatargas the vessels have many innovative features to maximize cargo deliveries and to ensure the highest levels of safety and reliability

5) The world's largest floating offshore facility – the Shell Prelude FLNG

Arriving offshore Australia in July 2017 Shell's Prelude Floating LNG (FLNG) is the world's largest floating offshore facility. Construction on the 600,000 tonnes facility started in October 2012 and saw the fabrication and assembly of more than 260,000 tonnes of steel. The 488 m long floating facility is larger than four football fields and includes a 93 m high mooring turret. It has an FLNG facility production capacity of at least 5.3m tonnes per annum (mtpa) of liquids: 3.6 mtpa of LNG, 1.3mtpa of condensate and 0.4mtpa of LPG. Currently in the hook-up phase Shell expects to see cashflow from operations in 2018.

6) The world's largest short sea RO-RO VESSEL MV CELINE CHRISTENED

With a capacity of 8,000 lane-meters, the super ferry, owned by Luxembourg-based CLdN, will be servicing Dublin Port The 235-meter long ship was constructed in South Korea's Hyundai Mipo Shipyard before being deployed to its homeports of Zeebrugge and Rotterdam. The vessel features a dual propulsion system allowing for emissions reduction. Luxembourg-based short sea specialist CLdN RoRo took delivery of the vessel in October 2017.

As you can see there is a tendency to build bigger vessels, this way money are being saved from fuels and also needs are met from the global demands that continuously grow.

Chapter 2: Repairing a vessel

2.1: The importance of repairing a vessel and reference to the regulations

The main purpose of a Dry Dock is to expose the underwater parts for inspection, repair and maintenance. The ship to be repaired is hence maneuvered into the lock and the gates are sealed post which all the sea water accumulated in the vessel is drained for better inspection and repairs. According to SOLAS, active ships that fall under the 100A5 category have to be subjected to a bottom survey twice every 5 years. Also, a Merchant Vessel which is older than 15 years needs to be checked for breaches or any defaults twice in every five years. In case of Passenger Ships, the repair period is every two years. Subjecting vessels to this process is a must if the Classification Society finds it necessary to carry out Dry Docking, in spite of the schedules outlined by SOLAS. This is usually the case if the ship has met with a collision, was grounded in past or has been subjected to poor maintenance practice. Inspection during dry docking is also carried out if the ship is to be sold.

2.1.1: Hull Cleaning

One of the most important types of underwater ship repair is hull cleaning and should be completed on a regular basis. Regular cleaning and upkeep of your ship's hull can affect its longevity and efficiency. By keeping the ship's hull clean and maintained, one can avoid nasty surprises such as barnacles, marine crustaceans that if left untreated can attach themselves permanently to the underside of the ship. What is more, a clean hull helps to streamline the ship, making it more fuel efficient and therefore cheaper to run. Hull cleaning involves propeller polishing, hull plate repairs and underwater ship painting, which will be presented next.

https://www.calveymarine.co.uk/blog/2016/07/21/importance-underwater-ship-repairs-maintenance/

Propeller Polishing

Regular propeller polishing can help to reduce the surface's roughness and in turn, can save significant costs further down the line. Smooth propeller surfaces become inhospitable to marine organisms, meaning the underside of the ship will not become a homing ground for marine life that could cause damage.

Hull Plate Repairs

Damaged hull plating can be the result of many factors; natural corrosion, stress from long voyages or unavoidable wear and tear after years of service. Allowing defective hull plates to go unnoticed can cost you, both financially and in time, so immediate repair and maintenance once a fault has been identified is important. Repair methods are varied; from a hydraulic ram to specialist tempering.

Underwater Ship Painting

There will undoubtedly be a time where underwater painting or adhesive work to the bottom of your ship is needed, particularly if any protective coating begins to deteriorate and corrode. Regular maintenance on your ship's paintwork can not only help deter such corrosion but save you money, if rust or oxidization is left for too long, it becomes a much more expensive problem to have.

2.1.2: Exceptions of the regulations

According to SOLAS regulation, every sea-going vessel has to undergo two dry docks within a period of 5 years. A ship in dry dock is a ship out of service. Dry dock is a complex process which is both expensive and time consuming. With two compulsory dry docks within a period of 5 years, it is a stressful task for ship owners and personnel who have to go through a lot of planning and preparation for the drydocking activity. Planning of dry docking starts several months before the scheduled date. A number of things needs to be arranged starting from the convenient place for dry-docking to arranging spares and on-shore maintenance staff. Moreover, it is often seen that ships have to take a totally different route for a suitable dry dock place as most of the time the desired facility is not available when needed. This is very common with larger vessels.
In order to deal with this situation, all major classifications societies have a special program called the “Extended Dry-Docking” or EDD scheme. Under extended dry-docking program, ships have a privilege to extend their dry docking period from 5 to 7.5 years. This means that vessels under this special program get maximum dry dock interval of 7.5 years by replacing certain dry-dockings by in-water surveys (IWS) which are carried out by approved diving companies. A variety of factors are taken into consideration before approving a ship for extended dry-docking. However, not every ship is allowed for the extended dry-docking program. The maximum dry docking period is extended by allowing the qualified ships to undergo In-Water Surveys (IWS) which help to increase the period between two dry-docks. However, only those ships which produce satisfactory results in these surveys are allowed to continue with the EDD program.
Each classification society has its own requirements to allow a ship under extended dry-docking period to ensure highest levels of quality and safety. Some of the main requirements for a ship to be allowed under this special program are the following:

- Presently, the extended dry-docking program is available for only container ships, general cargo ships, and multi-purpose dry cargo vessels. This means that ships such as tanker and passenger vessels and those subjected to Enhanced Survey Program (ESP) and Extended Hull Survey Program (EHSR) cannot opt for extended dry-docking.
- Ships belonging to all flag states cannot apply for the extended dry-docking program. The flag administration first needs to approve the type of vessel and the owner for the extended dry-docking scheme. A ship can apply for the EDD only if its flag state approves of the program.

- The age of the ship plays a major role during acceptance for the EED program. The ideal age for the commencement of Extended Dry Dock Program is between 0-5 years and less than 10 years. However, older ships can be considered for the program depending on the flag state, ship type, classification society and other design and operational factors.
- Inspection of hull and paint coating is one of the most important factors considered for extended dry-docking. The paint manufacturer provides the criteria for which the coating will be valid for 7.5 years. Several factors such as vessel speed, area of operation, vessel utilization, and idle time are taken into consideration while deciding the validity of the coating. High quality hull coating is an important requirement for extended dry docking.
- Anti-Corrosion system (corrosion protection) is an absolute must for EDD. Ships with high quality underwater coating are only allowed for the extended dry-docking. Moreover, sacrificial anodes attached to the hull must be capable for renewal in water and the impressed current corrosion protection system must be monitored for effectiveness. The ballast tanks must also have good coating condition.

The extended dry-docking (EED) scheme can be summarized as follows:

- Dry-docking period extends from 5 to 7.5 years
- Dry-docking is replaced by In-Water Surveys (IWS) from authorized underwater inspection service providers
- Only those ship types and operators approved by Flag administrators are considered for dry-docking survey
- Not all types of ships can apply for EDD
- Generally ships of age not greater than 10 years are considered for EDD
- Special requirements for hull condition and paint coating thickness are required
- Proper ship corrosion protection system is a must
- Results of IWS decide the next dry-docking schedule
- Requirements for a ship to be approved for EDD will vary across EDD service providers
- Special surveys can be assigned to ships if required
- The scheme can be discontinued anytime if the ship does not meet the stated requirements

2.2: Shipyards repairing huge vessels in limited time

Building a vessel requires the cooperation of different departments, a variety of docks and the work of thousands of workers and machines in order the biggest shipyards in the world to be competitive.

That is how some of the biggest shipyards in the world keep up. These include Ulsan Shipyard in South Korea and China State Shipbuilding Corporation Ltd in China.

Shipbuilding facilities at Ulsan shipyard, in South Korea, offer workshops and facilities within the shipyard. These are put up in such a way that the maximum efficiency of shipyard operations can be maintained. Out of the total area of 1,780 acres of the shipyard, the workshops cover approximately 395 acres. Ulsan shipyard has ten large-scale dry docks with nine Goliath cranes. This allows HHI (Hyundai Heavy Industries) to manufacture any type of ship of any size. These are the dry docks:

Dry Dock 1, which measures 390m x 80m and is equipped with two Goliath cranes, is used for constructing LNG carriers. HHI also built the world's first T-shaped dry-dock in 2009 creating additional space for Dock 1 measuring 165m long, 47m wide and 12.7m high.

Dry Dock 2 is 12.7m deep and measures 500m in length and 80m in breadth. It is equipped with two jib cranes.

Dry Dock 3, measuring 672m long and 92m wide, is the largest dock of the Ulsan shipyard. It is capable of undertaking simultaneous construction of a variety of ships and is provided with two Goliath cranes. Vessels of up to one million deadweight tonnes in capacity can be constructed at this site.

Dry docks 4 and 5 are comparatively smaller in size and can be used to construct ships of up to 150,000DWT and 70,000DWT respectively.

Dry docks 6 and 7 are specially equipped for the construction of naval ships and special-purpose vessels.

Dry docks 8 and 9 were completed in 1996 and are currently allocated for building VLCCs. HHI has an H-Dock, again the world's first dry dock for building offshore vessels. The H-dock measures 490m long, 115m wide and 13.5m high. The deep dock has a capacity of one million deadweight tonnes.

Next, I will present the biggest merging of all times which is happening in china and its results in order to keep repairing vessels in limited time and continue being competitive. China has completed the merger of China State Shipbuilding Corporation (CSSC) and China Shipbuilding Industry Company (CSIC) to create a new shipbuilding company. The new entity will retain the brand name of China State Shipbuilding Corporation Ltd. It will have approximately 147 scientific research institutes, listed companies and enterprises. The merged entity will have total assets of CNY790bn ($112.29bn) and employ 310,000 people. The merger will manage the largest shipbuilding and repair facilities in China. Supported by the shipping research and development abilities, the company will be able to fulfil the global technical standard and safety agreements. CSIC also consists of the country's main force on research and design of military ships. It has 28 scientific research institutes with over 360 major specialties involved, with about 30 000

technicians, six state-level laboratory centers, 150 large-scale laboratories and three state-level technological centers. CSIC is capable of developing and inventing new products with its strong scientific back up. CSIC is also the largest marine equipment manufacturer in the country. It has 38 plants producing marine diesel engines, marine equipment and auxiliary products including ship accessories for both military and civilian use. Some of these products are either produced under production licenses or technological transfer.

2.2.1: Types of dry docking for repairing

The type of Dry docking method selected depends on the type of the ship and the severity of maintenance and repair required. The four main types of Dry docking Methods are as follows of which the Floating and the Graving Dock are most common:

1. Graving/ Excavated Dock
2. Floating Dock
3. Syncrolift / Shiplift
4. Slipway, patent slip

Graving/ Excavated Dock

The graving or excavated dock is constructed on the land near the sea shore using concrete to build walls, blocks and gates. This is the most basic form of docking technique, where in the ship is maneuvered inside the dock and rested on the blocks post which the gates are closed and water is released from the ship.

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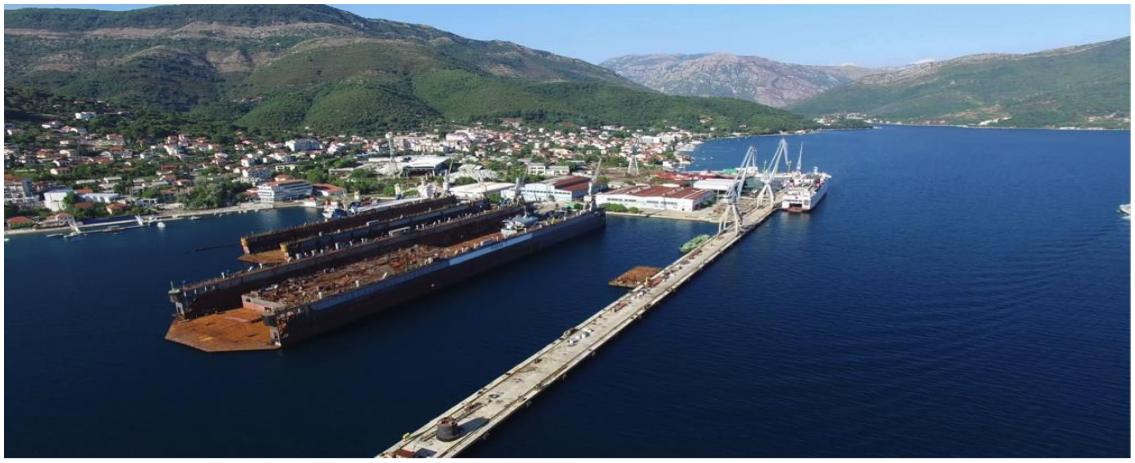
Floating Dock

Floating docks are specifically used to repair vessels that have met with accidents or broken down in the middle of the sea. A U shaped structure called pontoons is used to salvage ships from mid sea.

These U shaped structures are filled with water, which makes the dock go under water helping the ship to sail. Once the ship is secured and brought to the repair area, the water is released, making the dock to rise up and exposing the parts of ship that are otherwise underwater.



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Syncrolift / Shiplift

A syncrolift or a shiplift docking method is incorporated on ships that weigh from 800 to 25000 ton ship-weight. A floating dock makes use of the buoyant force of the pontoon, but in the Syncrolift, the ship is transferred onto a platform placed on the bed of the graving, and both ship and platform are heaved up on the land by winches installed on either side of the platform.

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Slipway, patent slip

Specifically meant for smaller boats, in Slipway, the hull is placed on trolleys and pulled ashore on the inclined surface using winches. The Marine railway is another type of Slipway docking technique, where an inclined plane extends from the shore to the water and the boat is hauled onto the cradle. This technique is usually used in case on repairs for larger ships weighing about 3000 ton in ship weight.

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2.2.2: Preparations on vessels before arriving on the dry dock and procedures on how dry docking is happening

Each company has included in the SMS (Safety Management System) the dry docking preparations and procedures for its own vessels. This is of what a vessel and its crew should prepare before arriving on the shipyard.

Preparing the Ship for Dry Docking:

1. Make a repair and maintenance list, create or obtain a drydock handbook if required, and assign responsible ship staff to their duties on the list. Divide staff into groups to oversee the work carried out by yard gangs.
2. All spare parts must be checked and repair items kept ready for use.
3. Previous dry dock reports should be studied and previous clearance measures noted.
4. Clean engine room tank top and bilges.
5. Prepare sewage treatment tanks, dirty oil tanks and bilge tanks.
6. Flushing of bilge lines is to be carried out prior to dry dock.
7. The oil-water separator filter element should be renewed and the system checked for satisfactory operation.
8. For tankers, all cargo tanks are cleaned and gas freed.
9. Minimum bunkers (Fuel Oil and Fresh water) and ballast carried.
10. All heavy weights secured prior to dry dock.
11. All tanks and cofferdams must be sounded and recorded.

12. Firefighting plans and safety measures discussed before dry dock
13. Firefighting equipment on board should be checked and kept ready for use.
14. Emergency lighting and generator should be tested before entry.
15. Escape routes must be clearly marked.
16. All valves and chests to be overhauled must be clearly marked.
17. Shore connections for cooling water and fire line are to be readied.
18. Main engine, generators, and boiler are changed over to diesel oil.
19. CO2 total flooding systems are secured and locked before entry.
20. Vessel must approach dock with even keel.

Regarding dry dock, there is a variety of works that need to be done and are described below in the queue of priority that is happening. After all that, the vessel obtains the new certificates and proceeds on its next destination.

Arrival at Yard and Entering the Dry-dock: After completing all necessary preparatory work, the vessel arrives at the shipyard. On completion of port formalities, the vessel proceeds to the dry-dock with assistance from tug boats and shipyard personnel. Prior to this, the blocks are arranged by the shipyards as per each vessel's specific docking plan.

Pumping down the Dock and Vessel "Taking" the Blocks: The water is drained from the dry-dock (generally overnight) over the course of about eight to ten hours, depending on the size of the vessel. Before the vessel is rested on the block, specialized dive teams ensure the block structures are in the correct location.

Ranging the Cables: The cables (or anchor chains) are ranged on the dock bottom once the dock is dry. Anchors and cables are then inspected and measured to determine the quality/ condition and defective parts are repaired or replaced as required. Hull Painting: The hull painting consists of washing, blasting and painting of the vessel and is one of the main reasons for dry-docking, as it ensures efficient vessel operations for the next five years. After extended periods of sailing and service, it is not uncommon for marine growth such as algae or slime to build up on the sides of the vessel. This buildup has a direct impact on the efficiency of the vessel and ultimately leads to higher fuel consumption.

Washing: Shipyard personnel use (fresh water) high-pressure washers to remove marine growth and chlorides from the ship side.

Blasting: Blasting is done primarily to remove rust or defective paint from the ship side. Depending on the need of each vessel, blasting may be localized or carried out along the entire side of the

vessel. In this process, old paint in the defective areas is removed entirely to expose the bare steel.
PAINTING: Once the blasting is completed, the entire vessel is cleaned and painted to protect the integrity of the steel and prevent future corrosion. The underwater side is painted with anti-fouling paint to prevent marine growth and ensures vessel operates close to its original design speed and fuel consumption.
Opening Sea Chests and Overhaul of Sea Valves: The sea chest is a recess in the hull of the ship that provides intake of sea water for the cooling systems in the engine room. This area is opened during the dry-docking process for cleaning, inspecting and painting. At the same time, all ship-side sea valves are inspected and overhauled as required.
Necessary Repairs and Maintenance: During this period, teams take the opportunity to carry our maintenance work on engines, pumps, tanks and cargo spaces as needed. Repairs on the rudder, propeller or shafting are made if any defects are identified.
Flooding the Dock: After all planned work has been satisfactorily completed, the dock is flooded and prepared for the vessel's departure.
Departure and Trials: The vessel is towed out of the dry-dock with the assistance of tugs and shipyard personnel. Once the vessel reaches a safe anchorage area, sea trails are carried out to confirm the operation of all ship's machinery. On completion of sea trials, the vessel is commissioned back into service.

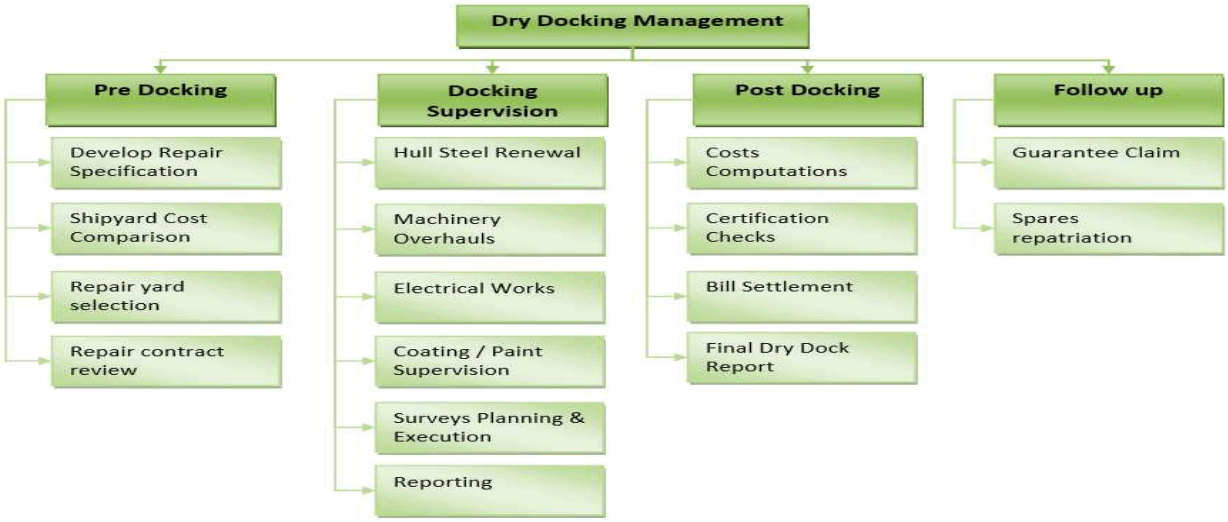
Moreover during the repair the dry dock itself has a variety of measures to take in order to ensure the safety:

1. Firefighting equipment ready at all times.
2. Fire detectors and fire alarm in good working condition.
3. CO2 total flooding system door is locked to prevent accidental actuation.
4. Safety gear worn while working- safety shoes, helmet, overalls, safety goggles, ear mufflers, and gloves.
5. Escape routes should be clearly marked.
6. Proper working permits obtained before carrying any work on board; e.g. hot work permit, enclosed space entry permit.
7. All lifting gears checked to be in good working condition.
8. Safety lamps are used – never use a naked lamp.
9. Co-ordination of work, so no chemical cleaning and hot work around boiler area is done at the same time.
10. No transfer of oil carried out in dry dock.

11. No boiler blow downs; in emergency, necessary notice given.
12. Acetylene and oxygen bottles are properly stored and secured.
13. Fire officer at site of work and extinguishers available.
14. No unauthorized personnel or chemicals allowed on board.
15. Ship properly grounded to shore earth.
16. Fire line is always ready with 2 hydrants open if no hull work is carried out.
17. Safety meetings should be carried out every morning before stating the work in dry dock.

2.2.3: Observation of the repair

It is important that things go right on dry dock because it is so big the cost for the ship owners, also, it is of huge importance for the future of the vessel everything to be fixed and all be ready before the vessel departs for the next voyage. So a lot of people are responsible for observing these procedures. The main procedures are going to be described below in accordance with the dry docking management.



https://www.marineinsight.com/guidelines/how-cost-estimation-is-done-for-ships-dry-dock/

The Superintendent Engineer has overall responsibility for the works, from start to finish. S/He has to issue the dry docking specification and prepare the budget, coordinate orders for stores and spares, select the shipyard, subcontractors and specialists, communicate with the Classification Society and other parties, as well as liaise with the Insurance Underwriters and Club Inspectors in case of Insurance or General Average Claims. Upon completion of the project, s/he must then attend

the sea trials, submit the final works reports and approve the invoices. The Superintendent Engineer cooperates closely with the relevant Marine Superintendent who is primarily dealing with safety-related issues on the vessel ensuring that the dry docking project itself occurs in a safe environment. Moreover every vessel has an agent to optimize the process and avoid conflicting interests between yard and ship owner. The scope of work involved in a dry-docking is complex and involves liaising with various parties - the ship agent has to establish good relations with the relevant Dry-docks. In addition, a ship agent has to liaise with all the concerned authorities, and suppliers and service providers, well before vessel arrival to ensure smooth operations. Also every vessel has its classification society which is responsible to supervise the repair of the vessel and after all check everything and issue the necessary certificates. Furthermore the dry dock itself has supervisors for each vessel, so all the above personnel have to co-operate, which is something difficult.

2.2.4: The equipment and technology being used on dry docks

Every dry dock has its own technology but some of them are in great demand because of their result. Regarding the equipment they have on dry docks, I will present the technology they use in order to achieve better performance on building vessels, the time it takes to build, on how to make them faster and so on.

This are the most popular technologies used on dry docks:

- As per the technology they make use of the latest analysis techniques to increase the structural strength. Therefore the ships should be designed and built in rational manner. Shipyards adopt an advanced three-dimensional (3-D) CAD system to the structural and outfitting design. It integrates each design phase. Shipyards are trying to develop higher performance ships by utilizing the cutting edge technology and facilities to attain customer satisfaction.
- They have developed an epoch-making energy-saving device called "STF". It consists of two pairs of flat-plate fins: one is attached in front of a propeller and the other on an afterpart shell ahead of it. The STF has a remarkable effect for reduction of the ships resistance and improvement of the propulsion efficiency by controlling bilge vortex occurring in flow around the afterpart body. The STF has proved its achievement of more than 5% energy saving in a sea trial.
- Newly developed High Lift Rudder Form (Patent) provides better maneuverability in comparison to conventional rudder form. This rudder can reduce rudder area attributed to high lift force compared to conventional one. Small rudder size also contributes to reduce the frictional resistance.

- Konecranes Gottwald Floating Cranes come into their own in harbors or waterways with limited quay facilities or none at all, and where quay capacities are exhausted. Based on well-proven Konecranes Gottwald mobile harbor crane technology, they can be used on a floating barge (turnkey solution): One barge, many benefits
    - Independent of landside handling facilities
    - Low specific investment costs
    - Short delivery lead times
    - Avoids lengthy approval procedures
    - No need for costly purchase of additional land or construction of new quays
    - More, larger vessels can be serviced in the port
    - Quay facilities unnecessary for direct transshipment between seagoing ship and barge
    - When additional capacity is required, floating cranes can supplement land-based handling
- Numerical control (also computer numerical control, and commonly called CNC) is the automated control of machining tools (drills, boring tools, lathes) and 3D printers by means of a computer. A CNC machine processes a piece of material (metal, plastic, wood, ceramic, or composite) to meet specifications by following a coded programmed instruction and without a manual operator.
- Shipbuilding Robotics**:** Recent trends suggest that the shipbuilding industry is recognizing robotics as a driver of efficiency along with a method to prevent workers from doing dangerous tasks such as welding. The shortage of skilled labor is also one of the reasons to look upon robotics. Robots can carry out welding, blasting, painting, heavy lifting and other tasks in shipyards. Geoje shipyard in South Korea which boasts of launching around 30 ships a year, 68% of its production processes is carried out by robotic systems which contributed to achieve it such a high production rate.

2.2.5: The approximate costs of the total procedure

Preparing a ship for a dry dock is not at all an easy task. A lot of planning is required in order to ensure smooth repairing work along with optimum ship repair cost. Every ship undergoes major repairing work during dry-dock period. Though there are several intermediate docking surveys and repairs scheduled in between, a five yearly dry dock is the one which involves major revamping of the ship. Needless to say, dry dock is an expensive process which requires systematic and efficient

planning and cost estimation to minimize overhead costs along with other unnecessary spending. Cost estimation plays an important role in order to keep a check on a ship's dry docking budget and to ensure a sensible quotation for the whole repair work. There are three important aspects of ship repair cost estimation:

- **Cost Groups**
- **Cost Parameter**
- **Work Breakdown Structure**

Cost Groups: Cost grouping is an integral part of cost estimation wherein the whole repairing process is divided into parts for the ease of cost quotation and work completion within the stipulated time. Cost groups also help to divide and assign work to different segments of the repair yard and to get individual quotation for each one of them, making the whole process smoother and manageable. Cost grouping is mainly done on the basis of ship's department. For example, deck, engine, electrical etc.

Cost Parameters: Cost parameter is an aspect of cost estimation which defines the total number of elements that are to be included for the final project cost. Cost parameters specify the limit and scope of activity during the repair work. Cost parameters help in analyzing the scope of the work and also help in considering each and every aspect taken into consideration for the dry dock.

Work Breakdown Structure: Work breakdown structure is an extension of cost grouping which further helps in distribution of jobs and procuring cost estimation for each job. Work breakdown structure helps estimating the time needed for whole process, including period of repair, dry docking period and lead time. It helps to figure out additional job quotations that would be required during the repair work. Based upon these parameters, quotations are asked for repair and spare from different agencies/yards, and eventually the best suited quotation is selected. The work breakdown structure also helps the chief engineer to decide what all jobs can be handled by the ship's staff within the stipulated time in order to save repair costs. This eventually helps in making the final quotation that is to be sent to ship yards.

General repair yard prices have increased 25-50 % in the last two or three years. Due to the high new-building rate on vessels and rigs, repair yards are facing problems getting enough and suitable manpower – in some areas the problem is considerable. There are even reports of an increasing number of vessels drawing and fitting tail-shafts afloat due to lack of dock slots. Certain periodic maintenance operations can only be performed when the vessel is in dry-dock, including the cleaning, sandblasting and coating of the hull with new antifouling paint. The most essential cost parameters are:

- Dry docking fees and repair yard cost

- Agency cost
- Classification surveyors' cost
- Cost of the stores
- Repair and maintenance cost
- Damage repair cost
- Cost of necessary spares

Below I will give the general costs for big vessels about the above parameters.

- The total cost of drydocking is substantial, ranging from USD 1.2 to 1.6 million for tankers, depending on vessel size
- The agency cost depends on a lot of things but the total cost is maximum 70-80 $ per day.
- In-house superintendent 600-900 $ per day plus travelling and accommodation expenses. Technical consultant us$ 1000-1400 per day travelling & accommodation expenses. Cost of repairs is between 700.000 us$ - 1.000.000 us$
- Cost in case of damage depends on a lot of things but generally is about 9,000,000 $ to take also into account the loss of earnings.
- Ships have spares to the tune of $ 0.5 million to 1 million, so depends on the needs of each vessel the cost varies.

So the total amount of repairing a vessel in dry dock is difficult to be determined.

Chapter 3: Dissolution of a vessel

3.1: Reasons for dissolution of the vessels and description of the procedure

Shipbreaking is dangerous work. It is the job of breaking down or demolishing a large ship to either dispose of or reuse the parts and materials. Most modern ships only last about 25 to 30 years and then they have to be recycled because of rust, corrosion, and metal fatigue. The ships become unsafe, but also become more expensive to operate because they require more repairs and maintenance. The maritime company that owns the ship can earn more from recycling such a ship. Ship breaking is the act of breaking down, dismantling, or taking apart a ship. The purpose is to recycle, scrap, or sell the parts of the ship to make money. Also another reason is if a type of vessel has low freight, which happened last year with the tanker vessels, especially the big ones due to the collapse of frame market on Vlcc it resulted in 200 tanker vessels to be sold for scrap. Steel is the main material that is recovered from ships to sell and recycle. Somewhere between 200 and 600 large ships reach the end of their life spans and are broken down in this way each year. The main

reason to retire a ship to the ship breaking yard is that it is costing too much money to operate. In addition to repairs and maintenance, ships incur other costs like wages for the crew, port charges, and oil fees. Ships are typically sold to a ship breaking company or recycler to be broken down. The original company owning the ship sells it in its entirety and then the recycler can break it down in any way it wants. Ship breaking is something that cannot be done quickly or easily. It is labor intensive and requires a lot of man hours. The process of ship breaking begins with draining a ship of any liquids. Then machinery, equipment, and fittings are taken out. Recyclers can sell batteries, copper wiring, engine oil, electronic dials, and even portholes. Once there is nothing but a steel shell left, workers use gas cutters and welding torches to cut the ship apart, piece by piece.

3.1.1: Types of dissolution

Shipbreaking can happen in a variety of ways, some are safer to human factor and environment while some are not:

1. **Shipbreaking on Beaches**

   It is being used on almost 95% of dissolutions today. During spring tides vessels go out closer to beach. If the vessel does not make it enough out on the beach, it is being cut on this position and while it is getting lighter they pull it closer with winches. This method is the cheapest of all because it harmful to the environment and dangerous to human life, it is being used in India, Bangladesh and Pakistan mainly.

2. **Landing or slipway shipbreaking**

   In this method the forward part of the vessel is on the land or in slips while the aft part of the vessel is afloat. All the work is done on the shore, parts of the vessel are being cut with the help of cranes and after that, they are being transferred to other locations in order to continue the cutting. Same as the previous method while the vessel gets lighter it is being pulled closer to shore. This method is mainly used in Turkey and the main difference is that due to absence of tide it is easier to control the leaks and decrease the environmental danger.

3. **Afloat or alongside shipbreaking**

   Hear the vessel stays afloat safe anchored parallel to a jetty. Parts are being cut from the vessel with the help of floating cranes and after they are being transferred to other locations. The procedure is being done from up to down until they reach the bottom

of the vessel, after, with the help of ballasting and de ballasting they dismantle the bottom. The last parts are sent in tanks for the final cut. This procedure is used in China. The consequences to environmental pollution are obvious, but due to no tide same as the previous type of dissolution, pollution can be controlled and after be cleaned.

4. **Dry method on tanks**

   In this method the dismantling of the vessel takes place in tanks and the waste can be collected without the pollution of the sea. Of course this is the safest option of all but till now it is not so popular due to its high cost. For now it is only happening in some countries of Europe.

3.1.2: Profits and reasons for choosing Asian shipyards

It is difficult to mention the profit a ship-owner has from selling a vessel for scrap because it depends on the price of the steel at that time, the weight of the vessel in tons, the place it is going for dissolution and the company that will buy it for this reason. Generally, there is avoidance from the European ship breaking yards due to the price a vessel is being sold in Europe compared to Asia. The companies in India, Pakistan and Bangladesh they buy vessels for 400-500 euro per ton, Chinese companies for 350 euro per ton, Turkish ones for 200-250 euro per ton and European ones for only 100-150 euro per ton. So the ship-owners see the dissolution as a way to gain profit. The yards have a good standing in Bangladesh. As an example, an estimated report in 2017 in Ship Breaking and Recycling Industry in Bangladesh and Pakistan concluded that the average profit from a Panamax oil tanker with 80,000 DWT is approx. $920,000.

3.1.3: Working conditions and accidents

Due to lack of protection, equipment, facilities and the poor working conditions, are obvious it is common to have accidents in the shipyards used for dissolution in India, Pakistan, Bangladesh. Beginning with the working conditions, I will present a relevant study of Geetanjoy Sahu, an Associate Professor of Tata Institute of Social Sciences (TISS):

- 66% of the workers have informed that provident fund amount from their salary is deducted every month. Out of these, only 20% of the workers have withdrawn their provident funds

so far and 46% have informed that the plot owners do not cooperate in processing their provident fund amount;

- 57% of the workers get access to drinking water from a facility in their yard, 12% do not get drinking water in their yard and the remaining workers, i.e. 31%, reveal that whilst a drinking water tap exists in the yard, the quality is not suitable for drinking or the water is not available regularly;
- 87% of the workers do not have access to a dinner hall facility in their work place. Only 12% of workers have access to a dinner hall facility in their work place, whereas 1% cannot use the dinner hall facility as it is only for show off;
- 60% of the workers have informed that the first-aid equipment is available in their yard, 29% do not have access or knowledge of a first-aid box in their yards and the remaining 11% stated that the first-aid box in their respective yard is only for show off;
- 30% of the workers have informed that the safety equipment is available to them in good quality, whereas 36% expressed their dissatisfaction over the quality of safety equipment and 16% have not received any safety equipment;
- In the absence of safety equipment and proper training, 52% of the interviewed workers were injured at workplace during the last year. Of these, 61% had received immediate medical support from their plot owners at the workplace and the remaining 39% did not receive any type of medical support from their plot owners;
- 30% of the workers were paid during their leave period due to injury, whereas 52% did not get any wage or compensation when they were on leave, and the remaining 18% continued to work despite their injuries as they were worried to loose wages;
- ASSBY has just three simple health facilities, two of them run by the Red Cross Society and a small clinic run by a private doctor. Neither have necessary facilities to treat major injuries and potentially fatal emergencies.

Regarding accidents, because there is so much that cannot be described and due to the absence of database by the district authority, about the number of workers at the shipbreaking yards, there does not exist a list with the total number of accidents and how many of them are fatal. Data collected by the Platform and Toxic Watch Alliance shows that there have been more than 500 fatal accidents since 1983 at the Alang shipbreaking yards – and at least 48 since 2014. Based on the findings of the TISS report, more than half of the total workers interviewed said they had been injured at their

workplace in the past year. 39 percent of these workers informed that they had not received any medical support; 52 percent did not get any wage or compensation when they were on leave due to injury; and, 18 percent continued to work despite their injuries as they were worried to lose wages. To give an example, in spring of 2016 a series of accidents led to four fatalities over the course of a few days. On one day a thirty year old worker died instantly when a large steel plate fell on him. Four others were injured in the accident. One of these men died later from the injuries. Within a few days, other accidents claimed two more workers and brought the death toll in Bangladesh ship breaking yards to ten for just the first five months of 2016.

https://en.wikipedia.org/wiki/Ship_breaking#/media/File:Jafrabad_Chittagong_shipbreaking_(8).JPG

3.1.4: Hazards related to human life

The environmental consequences are also dramatic. In June 2016, the EU directorate- General for the environmental published an overview of several studies, one of which clearly showed just how heavily the Alang-Sosiya natural environment has been polluted by copper, cobalt, manganese, lead, cadmium, nickel, zinc and mercury. The commission also refers to a previous study, published in 2001, that found that mercury levels in Alang were 15,500 percent higher than at a control site, and 16,973 percent higher for petroleum hydrocarbons. The researchers also detected the presence of certain bacteria at high levels.

Although awareness of the health risks of asbestos can be traced back to the early 1900s, the minerals continued to be used for decades afterwards. Asbestos use began to be restricted in the 1980s and it is now banned in 52 countries, yet approximately 125 million people worldwide are still exposed to it through their work environments. This includes those who work on ship recycling yards, as asbestos was used to provide thermal insulation in ships built in the 1960s and ‘70s. There is now indisputable scientific evidence that inhalation of asbestos causes cancer, including lung

cancer1 and mesothelioma, a rare form of cancer which develops in the linings of the lungs or stomach. A number of studies of shipyard workers have clearly shown increased mortality due to cancer. The ship recycling market hit a peak in the years following the financial downturn, bringing the issue of asbestos exposure to international attention. Although it is a recognized hazard, knowledge of the rates of asbestos-related disease among shipbreakers is lacking. Most studies have only assessed mortality which, while an important measure, does not record the many people with cancer who do not die from the disease (up to a third of sufferers). Therefore, this study looked at the link between cancer incidence and asbestos exposure. The study focused on former workers of shipbreaking yards in Taiwan, a center for shipbreaking between the 1980s and the end of the 1990s. The researchers used a matched cohort study, which means many workers were exposed in Asbestos.

Asbestos exposure increases risk of cancer in ship recycling workers Recycling ships for scrap is a known asbestos exposure hazard, yet this study is one of few to trace asbestos related cancer rates in shipbreaking workers. The results, obtained from former shipbreakers in Taiwan, show higher rates of cancer overall, especially esophageal and lung cancers.

Exposure in Shipbreaking Workers according to studies: Subjects were selected from a shipbreaking workers' union, whose membership includes 70% of people employed in the industry in Taiwan, and of which they must have been a member since 1985. Workers were assigned to matched controls from the general population based on age, gender and living area. In total, 4 427 shipbreaking workers and 22 135 controls were followed. The researchers used the same dataset to obtain cancer incidence for workers and the reference population: the Taiwan Cancer Registry, a record for new cancer cases, which was set up in 1979. The researchers assessed likely exposure to asbestos, differentiated by eight job titles: flame cutters, odd-jobbers, lifters, supervisors, knockers, sorters, drivers and administrators. The highest exposure job was flame cutter, and administrator the lowest. The researchers calculated Total Exposure Potential (TEP) scores for the workers based on their job title and years of employment. They were grouped into three categories of high, medium or low exposure. Finally, the researchers calculated hazard ratios (the risk of getting cancer over the study time period, compared to the likelihood in the control population) for various types of cancer, by job category and exposure. By the end of the 24-year follow up (2008), the researchers had collated data on 436 1. One study reported that shipyard workers were at a higher risk of mortality from lung cancer by a magnitude of 26%. Analysis showed that shipbreaking workers had a significantly higher risk of developing cancer compared to the general population. There was a significant increase in hazard ratio for overall cancer, oral cancer and lung cancer in all three asbestos exposure groups. Not only did the ship workers get cancer more often, they also got cancer younger. Furthermore, the relationship between cancer and asbestos exposure was dose-dependent

— i.e. the more asbestos the ship workers were exposed to, the more likely they were to develop cancer.

3.1.5: Environmental pollution

Though ship breaking has earned a good reputation for being a profitable industry in developing countries there are a number of environmental and human health hazards. Depending on their size and function, scrapped ships have an unladened weight of between 5,000 and 40,000 tons (the average being 13000+), 95% of which is steel, coated with between 10 and 100 tons of paint containing lead, cadmium, organotins, arsenic, zinc and chromium. Ships also contain a wide range of other hazardous wastes, sealants containing PCBs, up to 7.5 tones of various types of asbestos and; several thousand liters of oil (engine oil, bilge oil, hydraulic and lubricants oils and grease). Tankers additionally hold up to 1,000 cubic meters of residual oil. Most of these materials have been defined as hazardous waste under the Basel Convention. In Bangladesh, ships containing these materials are being cut up by hand, on open beaches, with no consideration given to safe and environmentally friendly waste management practices. Ships are not properly cleaned before beaching. Generally, an eyewash test is carried out to certify that a ship is free from dangerous chemicals and fumes. Ship breaking activities is a threat to both the terrestrial and marine environment as well as to public health. It is like a mini version of a city that discharges every kind of pollutants a metropolis can generate like liquid, metal, gaseous and solid pollutants.

Persistent Organic Pollutants (POP's): POPs are chemicals that are highly toxic, remain intact in the environment for long periods, become widely distributed geographically, bio accumulate through the food web, accumulate in the fatty tissue of living organisms and pose a risk of causing adverse effects to the human population, wildlife and the environment. There has been a realization that these pollutants, upon exposure of human population, can cause serious health effects ranging from increased incidence of cancers to disruption of hormonal system. Ship breaking activities are a source of lethal POPs.

Asbestos powder found near the ship breaking yards: Asbestos was used in old ships as a heat insulator. As there are no asbestos disposal procedures, during scrapping, workers and the surrounding environment are exposed to the asbestos fibers. Exposure to asbestos fibers (even in very low concentrations) especially through inhalation may cause cancer and asbestosis. On the ship breaking beaches, asbestos fibers and flocks fly around in the open air. Workers take out asbestos

insulation materials with their bare hands. It has also proven to be one of the most lethal, as inhaling asbestos fibers can lead to a wide range of pulmonary problems such as asthma and asbestosis – and can also be the direct cause of mesothelioma.

Heavy metals: Heavy metals are found in many parts of ships such as in paints, coatings, anodes and electrical equipment. These are taken apart with no protective measures in place and reused. Exposure can result in lung cancer, cancer of the skin, intestine, kidney, liver or bladder. It can also cause damage to blood vessels.

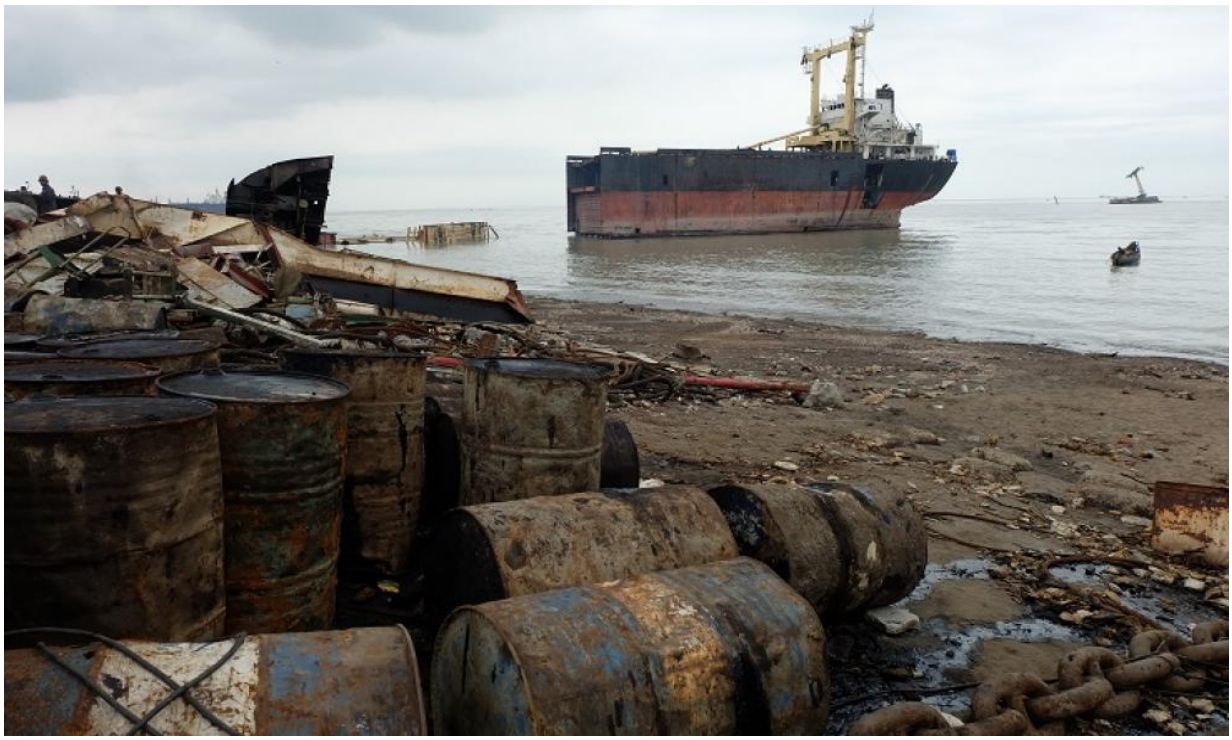
Oil spills from dismantled ships: As a result of breaking the ships, oil residues and the other refuses are being spilled, mixed with the sea water and left floating along the entire seashore. Oil may cause serious damage in different ways, such as a reduction of light intensity beneath the water surface which inhibits photosynthesis. Oil films on water reduce the exchange of oxygen and carbon dioxide across the air-sea interface which is harmful to aquatic life. It also causes damage to the bird population by coating their feathers with oil which causes buoyancy and insulation losses. Sometimes spilling may cause wide spread mortality amongst the population of fish, mammals, worms, crabs, mollusks and other water organisms.

Impact of ship breaking on physiochemical properties of seawater: Ship scrapping activities pollute the seawater environment in the coastal area of Fauzdarhat to Kumira of Chittagong, Bangladesh. As a result, toxic concentration of ammonia, marine organisms found in seawater had an increase in PH levels. Extensive human and mechanical activities accelerate the rate and amount of seashore erosion and results in higher turbidity of seawater. Critical concentration of DO and higher BOD were found with an abundance of floatable materials (grease balls and oil films) in the seawater.

Impact of shipbreaking on inter-tidal sediments and soils: In shipbreaking areas various refuse and disposable materials are discharged and spilled from scrapped ships and often get mixed with the sand. The scraps from the ships are staked haphazardly on the sea shore, leaving behind an accumulation of metal fragments and rust (particularly iron) in the soil. These together with extensive human and mechanical activities often go on as matter of routine work resulting in the beach soil losing its binding properties and this accelerates the amount of shore erosion and increase the turbidity of sea water and sediments in the area.

Impact of ship breaking on biodiversity: Shipbreaking activities contaminate the coastal soil and sea water environment mainly through the discharge of ammonia, burned oil spillage, floatable grease balls, metal rust (iron) and various other disposable refuse materials together with high

turbidity of sea water. The high PH of the seawater and soil observed may be due to the addition of ammonia, oils and lubricants. High turbidity of water can cause a decrease in the concentration of DO and substantially increase the BOD. Furthermore, oil spilling may cause serious damage by reduction of light intensity, inhibiting the exchange of oxygen and carbon dioxide across the air-sea water interface, and by acute toxicity. As a result the growth and abundance of marine organisms especially plankton and fishes may seriously be affected. Indiscriminate expansion of ship breaking activities poses a real threat to the coastal inter-tidal zone and its habitat.



https://theecologist.org/2018/oct/15/toxic-trade-obsolete-ships

3.2: Shipyards that dissolution takes place and reasons for choosing Asians shipyards

At present, the global center of the ship breaking and recycling industry is in South Asia. Three countries account for 70–80 percent of the international recycling market for ocean-going vessels, with two more covering most of the remaining market. Only about 5% of global volume is scrapped outside these five countries. These five countries are, which will be discussed next, are: India, Pakistan, Turkey, China and Bangladesh.

India

The ship breaking yard at Alang is located in the Saurashtra region of Gujarat off the Gulf of Cambay. It was set up in 1983 on a small scale along a 10-km stretch of sandy beach. The tidal, geographical, and climatic features make Alang an ideal ship breaking location. The yards in Alang are famous in the shipbreaking industry. They are located along the bank of the Arabian Ocean and concentrated around a coastal area named Alang of Vabhnagar, in the state of Gujarat, almost 3000 kilometers from Chittagong, Bangladesh. The Alang shipbreaking yards started scrapping ships in 1983. Estimates vary, but it has maybe 160 potential plots for use as ship recycling facilities. This place has the best continental shelf available for shipbreaking in the whole of Asia. At the same time, it is known for the highest tidal level (10 meters) in the country. The vast expanse of intertidal zone gets exposed during ebb (low) tide which makes it convenient for shipbreaking activity, whereas the high tide makes it possible to accommodate big ships. According to the Gujarat Maritime Board, a total of 415 ships were dismantled at the Alang facility, averaging 38.6 million tons of light ton displacement (LDT) against 28.2 million tons LDT in 2010-11.

Pakistan

The Pakistani ship-breaking industry is for this very reason situated mainly in Gadani, Balochistan, about 50 kilometers away from Karachi. A 10 kilometers long beachfront here plays host to as many old and tired ships as need be, as long as said need is below 125 ships. In its hey-day, this yard provided direct employment to around 30,000 people and was the largest ship-breaking operation in the world. From 1969 to 1983, Gadani was in the prime of its life. In the 80's, it produced a million tons of scrap metal each year, thus fueling the Pakistani steel industry like nothing else. During this time, the Pakistani government showed good business sense and did all it could to help the development of the industry. Infrastructure was developed, import duties were lessened, and the National Ship-Breakers' Association was given a voice. The effect of all this was a minor economic boom for the province of Balochistan, as the Balochistan Development Authority leased the Beachfront in Gadani out to the ship-breakers on a case-by-case basis and extracted revenue according to the tonnage of the ship being broken. This source of revenue for the impoverished province continues well into the present day, even after the operations at Gadani have slowed down significantly.

Turkey

Although Turkey is an Organization for Economic Cooperation and Development country, the environmental and working conditions are very similar to the ship-breaking countries in Asia. Ship-breaking in Aliaga began in mid-70's and officially in 1984 when the import of ship-for-scrap was allowed according to liberalization measures of that time. 423 thousand LDT dismantling operations had been engaged at Aliaga Ship Recycling in 2010 and have reached 390 thousand LDT

since January of 2011. As of July of 2011 660 thousand tons of iron was obtained from 275 ship recycling operation in the region. Also Aliaga Ship Recycling Region started to dismantle of aircraft carriers for the first time of the facility's history.

China

In China ships are broken in docks with cranes and machinery. But the working conditions are almost the same in ship-breaking yards as all over Asia, such as, insufficient protection.
In 2000, in an inspection of four Chinese ship-breaking yards it was found that workers were insufficiently protected against toxic and hazardous materials. Toxic waste was burnt in open fires. Asbestos was removed without proper protection for workers. The carcinogenic material was sold for reuse to industries producing heating systems. Yards were heavily polluted by oil, heavy metals and other toxic substances. Pollution had spread outside the yards as well.

Bangladesh

Chittagong Ship Breaking Yard is located in Faujdarhat, Sitakunda Upazila, Bangladesh along the 18 kilometres Sitakunda coastal strip, 20 kilometres north-west of Chittagong. Handling about a fifth of the world's total, it is the world's largest ship breaking yard, employs over 200,000 Bangladeshis, and accounts for around one-half of all the steel in Bangladesh.

Table 2.5 Reported tonnage sold for demolition by major vessel type and country of demolition, 2018 (Thousand gross tons)

	Bangladesh	India	Pakistan	Turkey	China	World total	Percentage
Oil tankers	5 989	1 946	2 824	66	14	**10 884**	**59.5**
Bulk carriers	1 115	465	829	18	53	**2 495**	**13.6**
General cargo ships	127	149	57	65	5	**405**	**2.2**
Container ships	620	402	38	54	152	**1 284**	**7.0**
Gas carriers	347	455	48	3	97	**951**	**5.2**
Chemical tankers	43	167	28	28	2	**268**	**1.5**
Offshore vessels	181	581	72	143	30	**1 156**	**6.3**
Ferries and passenger ships	..	171	..	14	..	**185**	**1.0**
Other	210	353	47	29	5	**673**	**3.7**
Total	**8 632**	**4 690**	**3 943**	**418**	**359**	**18 300.9**	**100.0**
Percentage	**47.2**	**25.6**	**21.5**	**2.3**	**2.0**	**100**	

Source: Clarksons Research.

Notes: Propelled seagoing vessels of 100 gross tons and above. Estimates for all countries available at http://stats.unctad.org/shipscrapping.

https://shipbreakingbd.info/ship-breaking-around-the-world/

3.2.1: Regulations and today's conditions

The European Parliament and the Council of the European Union adopted the Ship Recycling Regulation (EU SRR) on 20 November 2013. The objective of the Regulation is to reduce the negative impacts linked to the recycling of ships. From 31 December 2018, EU-flagged commercial

vessels above 500 GT must be recycled in safe and environmentally sound ship recycling facilities that are included on the European List of approved ship recycling facilities. The List was first established on 19 December 2016 and is periodically updated to add additional compliant facilities, or, alternatively, to remove facilities which have ceased to comply. The List comprises facilities operating globally. To be included in the European List, any ship recycling facility irrespective of its location has to comply with a number of safety and environmental requirements. Facilities operating in the EU are approved by their national authorities for listing. The European Commission assesses applications received from the ship recycling facilities located in third countries. The EU List functions as an important market differentiator for yards that have already invested in proper occupational safety and environmental standards. Whilst the Regulation brings forward the requirements of the 2009 Hong Kong Convention for the Safe and Environmentally Sound Recycling of Ships, it also includes additional safety and environmental requirements. Indeed, the EU SRR sets higher standards than the IMO's Hong Kong Convention – the beaching method is not allowed and requirements related to downstream toxic waste management as well as labor rights are included.

Moreover, EU listed ship recycling facilities are subject to a higher level of scrutiny: there is independent third party certification and auditing, and NGOs, are allowed to submit complaints should they have concerns that a listed facility is not operating in line with the Regulation. These are important safeguards that are alarmingly absent under the Hong Kong Convention regime. EU-listing is indeed the only guarantee that a yard has been independently certified and audited up against an acceptable standard. To ensure legal clarity and avoid administrative burden, ships covered by the new legislation will be excluded from the scope of the Waste Shipment Regulation. Non-EU flagged vessels sold for scrapping whilst in European waters will remain covered by the Waste Shipment Regulation.

European ships, as well as vessels sailing under the flag of a third country and calling at an EU port or anchorage, will furthermore be required to have on board an Inventory of Hazardous Materials (IHM).New vessels flying the flag of an EU member state are required to have on board a certified IHM (Inventory Hazardous Material) starting 31 December 2018. This means that vessels with building contracts signed after this date shall have the IHM certificate in the specifications. All EU-flagged vessels to be recycled after 31 December 2018 will be required to have a Ready for Recycling Certificate, which means, among others, these vessels shall only be sent to recycling facilities included in the European List of Ship Recycling Facilities (EU List). For vessels in operation and flying the flag of an EU member state, the certified IHM is required starting 31 December 2020. It should be noted that the EU SRR also affects non-EU-flagged vessels, since

vessels flying a third-country flag (non-EU flag) calling at a port or anchorage of an EU member state shall have a certified IHM starting 31 December 2020.

Conclusion

Even if a lot of things changed over the past centuries on cargo transfer, one thing stayed the same and this is that vessels continue to transfer over 95% of world's merchandise. Merchant shipping is here to stay for a lot of centuries to come. By reading this thesis s/he is going to improve his/her knowledge for dry docking, but also understand how important merchant shipping is for the economy of our world. So as we cannot stop producing vessels, we need to focus on how to reduce the accidents of vessels that cause marine pollution. We should also set more strict laws about the repairing of vessels and the inspection that is carried out after the finishing of dry dock, in order to minimize the possibility of an accident to occur and minimize the pollution to the environment. Last but not least, there is an immediate need to find a solution for the dissolution of vessels. It is not enough to vote for laws, we must also enforce them. During the last decades hundreds of people died in the Ship breaking yards of Asia, thousands more got ill due to the harmful environment of these areas and thousands sqm of coast were polluted. This, of course, has led to the death of uncountable fishes and animals. Humanity must stop thinking profit is above human life and the environment. To summarize ship owners have to stop sending their vessels for dissolution in shipyards that are not included in the European list and Governments have to inspect if all safety measures and precautions are taken in their shipyards- ship breaking yards. By reading this thesis I hope you become sensitized and more aware of the situation in dry docks.

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